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April 5, 1999

Assistant Commissioner for Patents
Washington, D.C. 20231

PATENT APPLICATION TRANSMITTAL LETTER

INVENTOR(S): **KENSUKE FUJIWARA**
TITLE : **LASER INTENSITY ADJUSTING METHOD**
ATTORNEY DOCKET NO: **32739M008**

Sir:

Transmitted herewith for filing are the following:

New patent application including 17 pages of text, a signed Declaration, 6 sheets o f formal drawings, (Figures 1-6), Recordation Cover Sheet and Assignment, Claim for Priority of Japanese patent application and counsel's check for the amount calculated below.

Filing Fee	$760
Total Claims (5 - 20 =) x ($18)	
Independent Claims (2 - 3 =) x ($78)	
Recordation Cover Sheet and Assignment	40
TOTAL FEES INCLUDED	**$800**

If any additional fees associated with this communication are required, please notify the undersigned attorney by telephone and charge the fees to Deposit Account 02-4300.

Respectfully submitted,

Michael A. Makuch, Reg. No. 32,263

MAM:bcl

Enclosures

LASER INTENSITY ADJUSTING METHOD

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a laser intensity adjusting method to be applied to an electrophotographic digital image forming apparatus of a digital copying apparatus, a digital printer or the like. More specifically, the present invention relates to a laser intensity adjusting method of adjusting the maximum intensity of laser light for irradiating the photoreceptor presenting a uniform potential given by the corona discharger, such that the potential of a photoreceptor portion exposed to laser of the maximum intensity is equal to a predetermined set potential.

Description of Related Art

In an image forming apparatus of a digital copying apparatus or the like, there is conducted, regularly or as necessary, a so-called potential correction for making correction such that the potential of the photoreceptor surface is equal to a predetermined value. The potential correction includes a so-called dark potential correction and a so-called residual potential correction. The dark potential correction refers to correction in which, with the photoreceptor not exposed to laser, the potential is

corrected by adjusting the bias voltage of the grid of the corona discharger. The residual potential correction refers to correction in which, with the photoreceptor exposed to laser, the potential is corrected by adjusting the maximum intensity of the laser light. Generally, residual potential correction is to be conducted in succession after dark potential correction.

Fig. 4 schematically illustrates the arrangement of an image forming apparatus A of a color digital copying apparatus, in the vicinity of the photoreceptor thereof.

The image forming apparatus A has at its center a drum-like photoreceptor 1. Disposed around the photoreceptor 1 are a corona discharger 2 for giving a predetermined uniform potential to the surface of the photoreceptor 1, a laser exposure unit 8 (of which laser light is shown by an arrow of L) for causing a surface portion of the photoreceptor 1 to be exposed to the laser light based on an image read by an image reading device (not shown), a potential sensor 3 for measuring the surface potential of the photoreceptor 1, developing units 4a - 4d for developing an electrostatic latent image on the surface of photoreceptor 1 formed by its exposure to the laser light of the laser exposure unit 8 (the developing units 4a - 4d arranged to respectively form toner images of yellow, cyanogen, magenta and black), a transferring belt 5 for

transferring, to transfer paper, the toner images on the photoreceptor 1 surface formed by the developing units 4a - 4d, and a cleaning unit 6 for cleaning residual toner remaining on the photoreceptor 1 surface. These component elements above-mentioned are disposed in this order in the rotational direction of the photoreceptor 1 or in the direction of an arrow Y1.

The following description will discuss the operational procedure of dark potential correction and residual potential correction with reference to Figs. 5 and 6.

At the dark potential correction (Step S51), the bias voltage of the grid of the corona discharger 2 is set to an optional value, and the potential (dark potential) of the photoreceptor 1 surface is measured by the potential sensor 3 with the photoreceptor 1 not exposed to the laser exposure unit 8. Based on a difference between the measured dark potential and the desired preset potential, using a relationship equation (linear equation) obtained through experiments or the like, the bias voltage is adjusted such that the dark potential is equal to the desired preset potential. The dark potential correction is relatively readily conducted in the manner above-mentioned because the relationship between the grid bias voltage and the surface potential of the photoreceptor 1 can be approximated using

a substantially straight line function.

In succession, residual potential correction is to be conducted on the photoreceptor 1 which has just been subjected to dark potential correction. The maximum intensity of the laser exposure unit 8 is set to an optional value (for example ① in Fig. 6), and then the surface of the photoreceptor 1 presenting a uniform potential given by the corona discharger 2 is exposed to the laser light of the laser exposure unit 8 (Steps S52 and S53). Then, the potential (residual potential) of the photoreceptor 1 surface is measured by the potential sensor 3 (Step S54). A linear equation (③ in Fig. 6) previously obtained through experiments or the like is then applied to the measured residual potential (② in Fig. 6) to calculate the laser intensity (⑤ in Fig. 6) for the desired preset potential (④ in Fig. 6) (Step S56). The laser intensity thus obtained is set as the maximum intensity (Step S57), and the operations of steps S53 - S57 are repeated until the residual potential obtained at the step S54 becomes substantially equal to the desired preset potential (Step S55).

The foregoing conventional residual potential correction is disadvantageous in view of much labor and time required. More specifically, according to the conventional residual potential correction, the solution is

searched using a linear equation previously obtained through experiments or the like. However, the actual relationship between laser intensity and residual potential is as shown in Fig. 6, and it is therefore difficult to linearly approximate this relationship. Thus, although the laser maximum intensity is gradually converged to the solution by repeating the steps S53 - S57, repeated operations are required in a large number of iteration times before the final solution is obtained.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a laser intensity adjusting method capable of readily making a residual potential correction in a shorter period of time.

The present invention provides a laser intensity adjusting method of adjusting the maximum intensity of a laser exposure unit for irradiating laser light to the photoreceptor surface to which a uniform potential is being given by a corona discharger, such that the potential of the photoreceptor portion exposed to laser of the maximum intensity is equal to a predetermined preset potential. According to the present invention, photoreceptor surface portions are exposed to laser lights of a plurality of laser intensities obtained by coarsely dividing a predetermined laser intensity, and the potentials of the photoreceptor surface portions exposed to the laser lights of the

plurality of laser intensities are detected (coarse-division potential detecting step). In the vicinity of the laser intensity corresponding to the potential which is the nearest to the predetermined set potential, out of the potentials detected at the coarse-division potential detecting step, the predetermined laser intensity is further finely divided to set a plurality of laser intensities, photoreceptor surface portions are exposed to laser lights of the plurality of laser intensities thus set, and the potentials of the photoreceptor surface portions exposed to the laser lights of the plurality of laser intensities are detected (fine-division potential detecting step). The fine-division potential detecting step is repeated until there is obtained potential equal to or substantially equal to the predetermined set potential, and there is set, as the maximum intensity, the laser intensity corresponding to the potential thus obtained.

According to the laser intensity adjusting method of the present invention, photoreceptor surface portions are exposed to laser lights of a plurality of laser intensities obtained by coarsely dividing an optionally set laser intensity, and the potentials of the photoreceptor surface portions are detected. When there is not obtained the desired preset potential, there are repeated operations of exposing photoreceptor surface portions to laser lights of

a plurality of further finely divided laser intensities and, detecting the respective potentials, until there is obtained potential equal to or substantially equal to the predetermined set potential. Thus, no adjustment is made with the use of approximation, but the whole adjustment is made based on actually measured values, enabling an accurate residual potential correction to be readily made with a less number of iteration times.

These and other features, objects and advantages of the present invention will be more fully apparent from the following detailed description set forth below when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a flow chart illustrating a laser intensity adjusting method according to an embodiment of the present invention:

Fig. 2 is a view illustrating an example of exposure portions (patches) formed on the photoreceptor;

Fig. 3 is a view illustrating the residual potential correction operation according to the embodiment of the present invention;

Fig. 4 is a view schematically illustrating the arrangement of an image forming apparatus A of a color digital copying apparatus;

Fig. 5 is a flow chart illustrating the operational

procedure of a laser intensity adjusting method of prior art; and

Fig. 6 is a view illustrating the residual potential correction operation of prior art.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The following description will discuss an embodiment of the present invention for better understanding thereof. It is however noted that the following embodiment is a mere example embodying the present invention, and does not limit, in nature, the technical scope thereof.

Fig. 1 is a flow chart illustrating a laser intensity adjusting method according to an embodiment of the present invention; Fig. 2 is a view illustrating an example of exposure portions (patches) formed on the photoreceptor; Fig. 3 is a view illustrating a residual potential correction operation according to the embodiment of the present invention; and Fig. 4 is a side view schematically illustrating the arrangement of an image forming apparatus A of a color digital copying apparatus.

Likewise in the method of prior art above-mentioned, the description will be made, in this embodiment of the present invention, of a laser intensity adjusting method which is applied to an image forming apparatus A of a color digital copying apparatus as shown in Fig. 4.

The image forming apparatus A has at its center a

drum-like photoreceptor 1. Disposed around the photoreceptor 1 are a corona discharger 2 for giving a predetermined uniform potential to the surface of the photoreceptor 1, a laser exposure unit 8 (of which laser light is shown by an arrow of L) for causing a surface portion of the photoreceptor 1 to be exposed to the laser light based on an image read by an image reading device (not shown), a potential sensor 3 for measuring the surface potential of the photoreceptor 1, developing units 4a - 4d for developing an electrostatic latent image on the surface of photoreceptor 1 formed by its exposure to the laser light of the laser exposure unit 8 (the developing units 4a - 4d arranged to respectively form toner images of yellow, cyanogen, magenta and black), a transferring belt 5 for transferring, to transfer paper, the toner images on the surface of the photoreceptor 1 formed by the developing units 4a - 4d, and a cleaning unit 6 for cleaning residual toner remaining on the surface of the photoreceptor 1. These component elements above-mentioned are disposed in this order in the rotational direction of the photoreceptor 1 or in the direction of an arrow Y1.

The laser exposure unit 8 is arranged such that the laser maximum intensity can optionally be set and that the set maximum intensity (P_{MAX}) can be divided by a predetermined number (1023 in this embodiment) and laser light of each

intensity (P_{MAX} X x/1023)(x = 0, 1, 2, 3, ……) can be irradiated to the photoreceptor 1.

Referring to the flow chart in Fig. 1, the following description will discuss the operational procedure of the laser intensity adjusting method of the present invention.

In a manner similar to that in the prior art, dark potential correction is to be conducted (Step S1). More specifically, the bias voltage of the grid of the corona discharger 2 is set to an optional value, and with the photoreceptor 1 not exposed to the laser exposure unit 8, the potential (dark potential) of the photoreceptor 1 surface is measured by the potential sensor 3. Based on a difference between the measured dark potential and the desired preset potential, using a relationship equation (linear equation) obtained through experiments or the like, the bias voltage is adjusted such that the dark potential is equal to the desired preset potential.

In a subsequent residual potential correction, the maximum intensity P_{MAX} of the laser exposure unit 8 is set (Step S2). This P_{MAX} value is set somewhat high such that it will be higher than the final preset value (unknown). The maximum intensity P_{MAX} thus set is divided by 1023 and some laser intensities are selected at relatively coarse intervals in a range which is considered to contain the final preset value (Step S3). For example, there may be selected

five laser intensities P_{MAX} x (920/1023), P_{MAX} x (940/1023), P_{MAX} x (960/1023), P_{MAX} x (980/1023), and P_{MAX} x (1000/1023).

In succession, the surface of the photoreceptor 1 is exposed to laser lights of the laser intensities thus selected (Step S4). More specifically, exposure portions (patches A1 ~ A5) are continuously formed, by the respective laser lights of laser intensities, on the surface of the photoreceptor 1 as shown in Fig. 2 for example. The potentials (residual potentials) of the respective patches are measured by the potential sensor 3 (Step S5). Fig. 3 shows an example of the measured potentials of the respective patches. The operations of steps S2 - S5 correspond to a coarse-division potential detecting step or a first potential detecting step.

When there is found, in the measured residual potentials of the patches, potential equal to or substantially equal to the desired preset potential (that is, when a predetermined finish condition is satisfied) (YES at step S6), the laser intensity for the patch of which potential is equal to or substantially equal to the desired preset potential is adopted as the final maximum intensity, and the processing is finished.

On the contrary, when there is not found, in the measured residual potentials of the patches, potential equal to or substantially equal to the desired preset

potential (that is, when a predetermined finish condition is not satisfied) (NO at step S6), some laser intensities at fine intervals are selected in the vicinity of the laser intensity for the patch of which potential is the nearest to the desired preset potential (Step S7). For example, it is now supposed that the desired preset potential is -200V and the patch A3 presents a residual potential of -198V. In such a case, a region lower than P_{MAX} x (960/1023) is further finely divided. For example, there are selected five laser intensities P_{MAX} x (950/1023), P_{MAX} x (952/1023), P_{MAX} x (954/1023), P_{MAX} x (956/1023), and P_{MAX} x (958/1023). Then, using these laser intensities thus selected, the operations of the steps S4 - S6 are repeated. Thereafter, the step S7 and the steps S4 - S6 are repeated until the finish condition is satisfied at the step S6. The step S7 and the steps S4 - S6 correspond to a fine-division potential detecting step or a second potential detecting step.

When the finish condition is satisfied at the step S6, there is adopted, as the final maximum intensity, the laser intensity for the patch of which residual potential is equal to or substantially equal to the desired preset potential.

According to the laser intensity adjusting method of the embodiment having the arrangement above-mentioned, the photoreceptor 1 surface is exposed to laser lights of a

plurality of laser intensities obtained by coarsely dividing an optionally set maximum intensity P_{MAX}, and the respective potentials are detected. When there is not obtained the desired preset potential, there are repeated operations of exposing photoreceptor 1 surface portions to laser lights of a plurality of further finely divided laser intensities and detecting the respective potentials, until there is obtained potential equal to or substantially equal to the predetermined set potential. Thus, no adjustment is made with the use of approximation, but the whole adjustment is made based on actually measured values, enabling an accurate residual potential correction to be readily made with a less number of iteration times.

An embodiment of the present invention has thus been discussed in detail, but this embodiment is a mere specific example for clarifying the technical contents of the present invention. Therefore, the present invention should not be construed as limited to this specific example. The spirit and scope of the present invention are limited only by the appended claims.

This application claims priority benefits under 35 USC Section 119 of Japanese Patent Application Serial No. H10-109782, filed on April 20, 1998 with the Japanese Patent Office, the disclosure of which is incorporated herein by reference.

What is claimed is:

1. A laser intensity adjusting method of adjusting a maximum intensity of a laser exposure mechanism for irradiating laser light to a surface of a photoreceptor to which a uniform potential is being given by a corona discharger, the method comprising:

a coarse-division potential detecting step of (i) exposing photoreceptor surface portions to laser lights of a plurality of laser intensities obtained by coarsely dividing a predetermined laser intensity, and (ii) detecting potentials of the photoreceptor surface portions exposed to the laser lights of the plurality of laser intensities;

a fine-division potential detecting step of (i) further finely dividing, in the vicinity of a laser intensity corresponding to a potential which is a nearest to a predetermined set potential out of the potentials detected at the coarse-division potential detecting step, the predetermined laser intensity to set a plurality of laser intensities, (ii) exposing photoreceptor surface portions to laser lights of the plurality of laser intensities thus set, and (iii) detecting potentials of the photoreceptor surface portions exposed to the laser lights of the plurality of laser intensities; and

a step of (i) repeating the fine-division potential

detecting step until there is obtained potential equal to or substantially equal to the predetermined set potential, and (ii) setting, as the maximum intensity, the laser intensity corresponding to the potential thus obtained.

2. A laser intensity adjusting method of adjusting a maximum intensity of a laser exposure mechanism for irradiating laser light to a surface of a photoreceptor to which a uniform potential is being given by a corona discharger, the method comprising:

a first potential detecting step of (i) exposing photoreceptor surface portions to laser lights of a plurality of laser intensities set at first intervals, and (ii) detecting potentials of the photoreceptor surface portions exposed to the laser lights of the plurality of laser intensities;

a second potential detecting step of (i) exposing photoreceptor surface portions to laser lights of a plurality of laser intensities which are set, at second intervals smaller than the first intervals, in the vicinity of a laser intensity with which there has been detected, at the first potential detecting step, a potential which is a nearest to a predetermined set potential, and (ii) detecting potentials of the photoreceptor surface portions exposed to the laser lights of the plurality of laser intensities; and

a step of setting, as the maximum intensity of the laser exposure mechanism, a laser intensity with which there has been detected, at the first or second potential detecting step, potential equal to or substantially equal to the predetermined set potential.

3. A laser intensity adjusting method according to Claim 2, wherein

the second potential detecting step is repeated until there is obtained potential equal to or substantially equal to the predetermined set potential.

4. A laser intensity adjusting method according to Claim 2, wherein

the laser intensities set at first and second potential detecting steps have values selected from a plurality of laser intensities obtained by dividing the predetermined laser intensity by a predetermined number.

5. A laser intensity adjusting method according to Claim 4, wherein

the predetermined laser intensity is set to a value which is considered to be greater than a suitable maximum intensity.

ABSTRACT OF THE DISCLOSURE

A method of adjusting the maximum intensity of a laser exposure mechanism for irradiating laser light to the surface of a photoreceptor to which a uniform potential is being given by a corona discharger. Photoreceptor surface portions are exposed to laser lights of a plurality of laser intensities obtained by coarsely dividing an optional laser intensity, and the potentials of the photoreceptor surface portions are detected (coarse-division potential detecting step). In the vicinity of the laser intensity corresponding to the potential closest to the desired preset potential, the predetermined laser intensity is further finely divided to set a plurality of laser intensities, photoreceptor surface portions are exposed to laser lights of the plurality of laser intensities thus set, and the potentials of the photoreceptor surface portions are detected (fine-division potential detecting step). The fine-division potential detecting step is repeated until there is obtained potential equal to or substantially equal to the desired preset potential, and there is set, as the maximum intensity, the laser intensity corresponding to the potential thus obtained.

FIG. 1

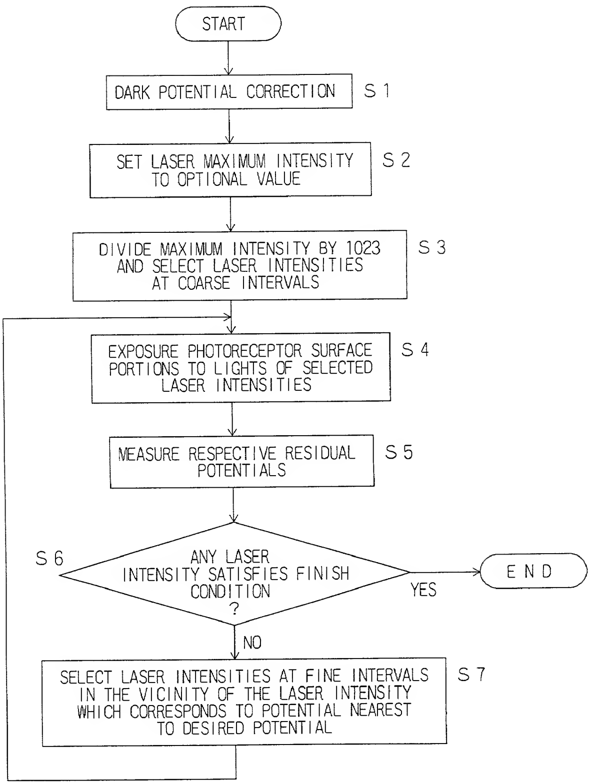
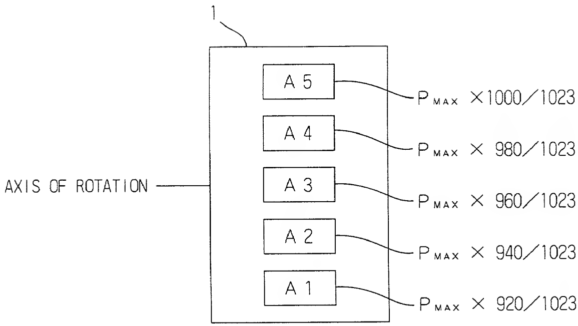
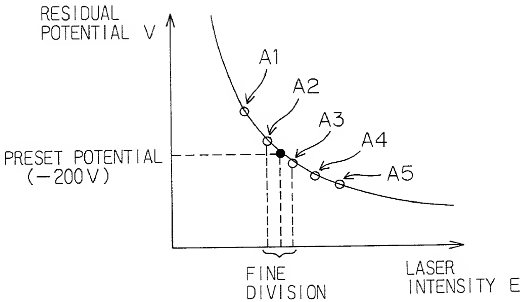

START
DARK POTENTIAL CORRECTION
S 1
SET LASER MAXIMUM INTENSITY TO OPTIONAL VALUE
S 2
DIVIDE MAXIMUM INTENSITY BY 1023 AND SELECT LASER INTENSITIES AT COARSE INTERVALS
S 3
EXPOSURE PHOTORECEPTOR SURFACE PORTIONS TO LIGHTS OF SELECTED LASER INTENSITIES
S 4
MEASURE RESPECTIVE RESIDUAL POTENTIALS
S 5
S 6
ANY LASER INTENSITY SATISFIES FINISH CONDITION ?
YES
END
NO
SELECT LASER INTENSITIES AT FINE INTERVALS IN THE VICINITY OF THE LASER INTENSITY WHICH CORRESPONDS TO POTENTIAL NEAREST TO DESIRED POTENTIAL
S 7

FIG. 2

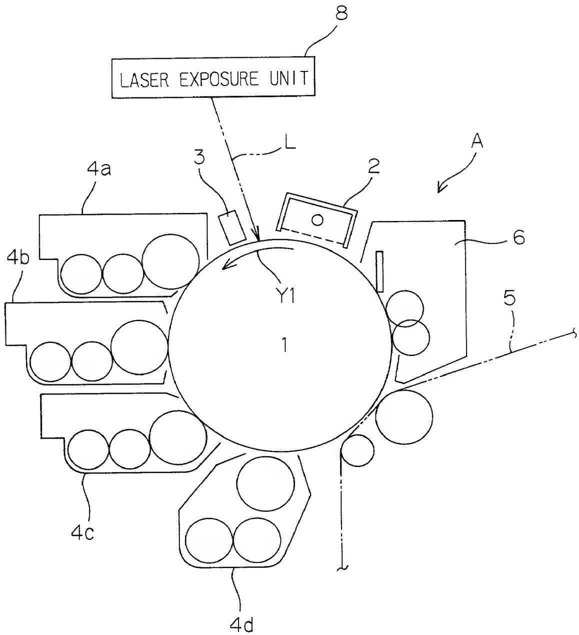

1
A5
A4
A3
A2
A1
AXIS OF ROTATION
PMAX ×1000/1023
PMAX × 980/1023
PMAX × 960/1023
PMAX × 940/1023
PMAX × 920/1023

F I G. 3

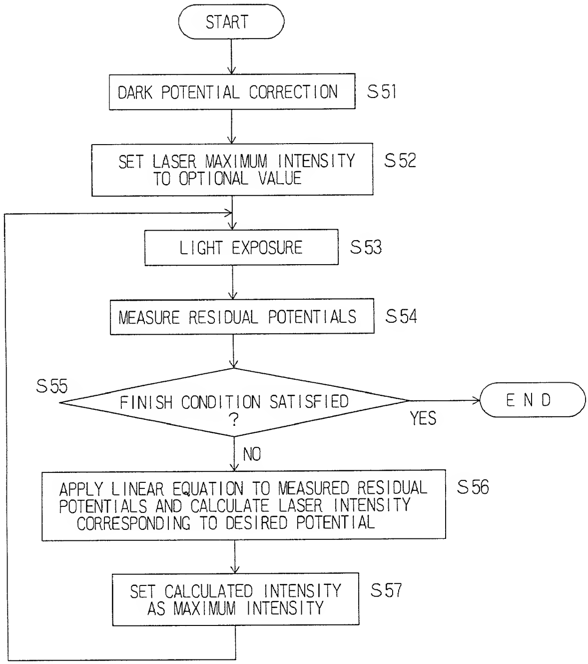


RESIDUAL POTENTIAL V
A1
A2
A3
A4
A5
PRESET POTENTIAL (−200V)
FINE DIVISION
LASER INTENSITY E

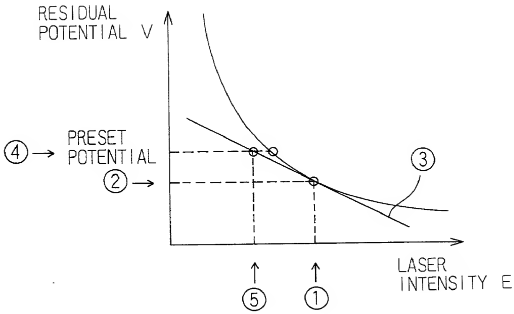
FIG. 4



F I G. 5


START
DARK POTENTIAL CORRECTION
S51
SET LASER MAXIMUM INTENSITY TO OPTIONAL VALUE
S52
LIGHT EXPOSURE
S53
MEASURE RESIDUAL POTENTIALS
S54
S55
FINISH CONDITION SATISFIED ?
YES
E N D
NO
APPLY LINEAR EQUATION TO MEASURED RESIDUAL POTENTIALS AND CALCULATE LASER INTENSITY CORRESPONDING TO DESIRED POTENTIAL
S56
SET CALCULATED INTENSITY AS MAXIMUM INTENSITY
S57

F I G. 6


RESIDUAL
POTENTIAL V
4
PRESET
POTENTIAL
2
3
LASER
INTENSITY E
5
1

UNITED STATES (Form BDWY-1)
Patents and Design Patents
Sole & Joint Inventors
Convention & Non-convention
PCT & Non-PCT
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Declaration and Power of Attorney
United States Patent Application

As a below named inventor, I hereby declare that:
My residence, post office address and citizenship are as stated below next to my name.
I believe I am the original, first and sole inventor *(if only one name is listed below)* or an original, first and joint inventor *(if plural names are listed below)* of the subject matter which is claimed and for which a patent is sought on the invention entitled
LASER INTENSITY ADJUSTING METHOD
______, the specification of which

(check one) XX is attached hereto.
☐ was filed as U.S. Application No.______ on ______ and *(if applicable)* was amended on ______.
☐ was filed as PCT International Application No.______ on ______ and *(if applicable)* was amended under PCT Article 19 on ______.

I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119(a)-(d) or §365(b) of any foreign and PCT application(s) for patent or inventor's certificate, or §365(a) of any PCT international application which designated at least one country other than the United States of America listed in this Declaration. I have also identified below any foreign application for patent or inventor's certificate or PCT international application having a filing date before that of the application(s) on which priority is claimed:

Foreign/PCT Application No.	Country	Filing Date	Priority Claimed? (yes/no)
No. 10-109782	Japan	April 20, 1998	Yes

I hereby claim the benefit under Title 35, United States Code, §120 or §365(c) of any United States application and PCT international application designating the United States of America listed in this Declaration and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application or PCT international application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

U.S. Application No.	Filing Date	*Status (patented/pending/abandoned?)*

I hereby claim priority benefits under Title 35 United States Code §119(e) of any U.S. provisional application(s) listed below:

U.S. Provisional Application No.	Filing Date

I hereby appoint the following attorneys to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: Joseph A. DeGrandi (17446), Robert G. Weilacher (20531), Richard G. Young (20628), Michael A. Makuch (32263), Dennis C. Rodgers (32936), Thomas L. Evans (35805), Maurice U. Cahn (30454), Frank C. Cimino, Jr. (39945), and Carolyn A. Favorito (39183).

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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Signature: Kensuke Fujiwara Date: 3/19/1999
(Month/Day/Year)

☐ Additional inventors and/or prior applications are listed in attached Supplemental Sheet(s). BDWY 1196